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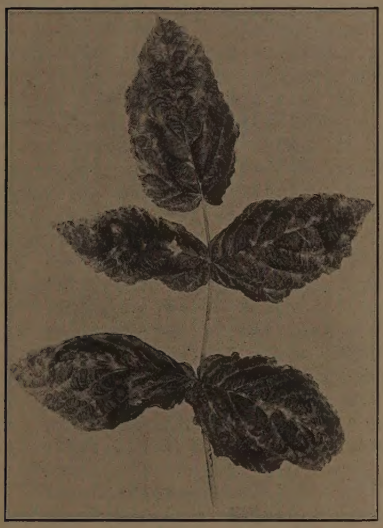
By C. W. BENNETT



AGRICULTURAL EXPERIMENT STATION
MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

BOTANICAL SECTION

East Lansing, Mich.

Michigan Raspberry Diseases

C. W. BENNETT

Raspberry growing in Michigan has developed into an industry of considerable economic importance. The 1920 census credits the state with 9,786 acres of this fruit. The yield is placed at 7,652,580 quarts and the value of the crop at $1,760,100. Estimates indicate that during the past seven or eight years the industry has expanded until at the present time there are probably more than 10,000 acres of raspberries in the state.

The acreage is more or less concentrated in certain areas. Berrien county grows about half of the total crop. Other large producing counties are Manistee, Van Buren, Sanilac, Ottawa, and Muskegon.

Manistee and Sanilac counties grow reds almost exclusively, the Cuthbert is by far the leading variety. Most of the black raspberries are grown in the southwestern part of the state. It is estimated that more than three-fourths of these black raspberries are of the Cumberland variety. This same section grows a great many reds of the King variety but only a small acreage of Cuthberts. The Latham is now well established and will probably become a strong competitor of the King. The St. Regis is grown in many parts of the state but chiefly in small plantings for home use. Other red varieties grown on a small scale are Viking, Marlboro, and Ohta. The Columbian is the leading purple variety. Royal Purple and Cardinal are grown in small quantities. Although Cumberland is the leading black variety, others such as Plum Farmer, Kansas, Gregg, and Honey Sweet are quite popular and are grown quite extensively.

The concentration, within limited areas, of this rather large number of raspberry varieties from all parts of the United States, has not only led to the introduction of numerous diseases, but has also afforded favorable conditions for spread of these diseases. Since the raspberry has been a plant of relatively minor importance, the diseases to which it is subject have not, until recently, been given any considerable attention. As a result, the diseases themselves and the control measures have not been so well understood as are the troubles of some of the crops of greater money value. It is the purpose of this bulletin to describe rather fully the diseases which are of importance on raspberries in Michigan and to suggest such control measures as seem of value in this state.

VIRUS DISEASES

In nearly all of the raspberry growing sections of the United States and Canada, growers have noted a tendency on the part of varieties of raspberries to "run-out" or decline in productiveness until they are no longer

profitable. Among the varieties of this type are the Marlboro, Perfection, and Empire. Others such as the Cuthbert, Latham, and King have in certain sections shown a marked decrease in yielding capacity. For a long time "running-out" was attributed to a disease called "yellows." In recent years it has been found that there are several distinct diseases responsible for "running-out" of varieties. All of these have probably been called yellows at one time or another. These diseases, for convenience of arrangement, are discussed under the headings curl, mosaic, and streak. The cause of these diseases in each case is believed to be a virus which permeates the tissues of the affected plants and remains active so long as the plant lives. Some of the viruses are quite virulent and require only a short time in which to kill plants of the more susceptible varieties; others are milder in their influences and require several years to produce any noticeable effects. The effect of a particular virus also depends to a considerable extent on the variety attacked.

The viruses are carried from plant to plant by aphids or plant lice. They are not, however, believed to be spread by pruning or other cultural practices.

Curl

Distribution and Economic Importance. Curl has been known for many years and is very common and widespread. It is found in all parts of the United States and Canada where raspberries are grown. On susceptible varieties it causes considerable loss. Of the red varieties, Cuthbert, Marlboro, Latham, and Viking are quite susceptible. King, Ohta, and Ranere (St. Regis) are very resistant. Of the blacks, Cumberland and Gregg are susceptible and Kansas and Plum Farmer are more resistant. The purple variety Haymaker is susceptible to this disease. Columbian, Royal Purple, and Cardinal seem to be quite resistant.

Symptoms. Due to the dwarfed condition, compact appearance, and deep green color of the affected plants, curl is one of the easiest of virus diseases to recognize in the field. Leaves are markedly curled or rolled downward and inward at the edges. The symptoms are distinct almost from the time of first growth in the spring until the leaves are off in the fall. Towards the end of the season, affected plants usually take on a bronze color. Canes are short and weak and winter-kill badly. Plants usually do not live more than three or four years after they become diseased.

Fruits are so small and of such poor quality that they are rarely harvested. In counts made in 1927 from a field of Cuthberts, an average of 607 berries from curl plants was required to fill a quart box, while an average quart of healthy fruit contained only 401 berries. Diseased berries were also lighter, a quart weighed only 605 grams as compared to 667 grams the average weight of a quart of berries from healthy bushes. The reduction in the yield of blacks is even greater and often fruits become very hard and dry before picking time.

Spread. This disease is spread from plant to plant by a small plant louse, *Aphis rubiphila*, which, in the fall, lays its eggs on the canes near the base of the buds or on the buds themselves, where the eggs may be seen as shiny black objects which are smaller than the head of a common pin.

In the spring, these eggs hatch and the young aphids crawl to the young unfolding leaves where they feed and multiply very rapidly, first forming colonies but later scattering to all parts of the plant. These aphids are

quite small and very sluggish. Except in the winged stages, they do very little moving from one plant to another unless disturbed.

As a result curl usually spreads slowly from plant to plant along the row. Sometimes, however, the disease spreads more rapidly over a field, probably due, in most cases, to the production of many winged aphids capable of flying or being carried by the wind to plants in different parts of the planting. Possibly other species of aphids are capable of carrying the curl virus

Fig. 1.—A four-year-old Cuthbert red raspberry plant showing curl. This plant had been diseased for about a year.

but the evidence now at hand indicates that the little aphid which has been described is responsible for the great majority, if not practically all, of the spread of curl in raspberries.

The rate of spread is dependent, to a large extent, on the season, the variety affected, and on the location of the planting. Curl spreads more rapidly in Cuthbert and Cumberland than in King or Gregg. In some cases, Cuthbert and Cumberland patches which have five per cent of curl during the first year may have eighty per cent of the plants affected by the fourth year. Curl will spread from blacks to susceptible reds but rarely spreads from reds to blacks. Apparently, there are two strains of the curl virus, one of which causes disease in both blacks and reds, and another which causes disease in blacks. Both strains will attack the hybrid variety Columbian; the more severe curling is caused by the virus from the black varieties. The virus which attacks reds seems to be more common than the one

which attacks black varieties. Curl seems to spread more rapidly in plantings near buildings. This seems to be associated with an increased aphid population and with a greater chance for distribution and dissemination of aphids.

Control. Since aphids are responsible for the spread of curl, it might seem at first thought that a spray which would reduce the number of aphids would constitute one of the best control measures. Spraying for aphids, however, is rather expensive and, moreover, in fields in which this method of control has been tried, the reduction in spread of curl has not been satisfactory. A more economical and effective measure consists in destruction of diseased plants as soon as they can be detected. Curl is easily controlled

Fig. 2.—A curled Cuthbert plant in a first year field. In this stage of development of the planting, roguing is very effective.

in this way in young plantings. If such patches are rogued two or three times the first year the disease can be practically eliminated. The best procedure is to go through the planting as soon as growth is well started and pull out all visibly diseased plants. Diseased plants should be buried, burned, or carried to a distance from the patch so that aphids which are present will not find their way to healthy plants and spread disease. If growth of the new plants is not uniform and some of the plants are late in starting, roguing should be repeated every two or three weeks throughout the first half of the season.

Curl is much more difficult to control if rouging is delayed until after the first year. The older the planting the more difficult control becomes. Control is more difficult in reds than in purples and blacks because of the extensive suckering of the red varieties. However, even in old patches not too heavily infested the disease can be controlled by roguing if the proper precautions are taken. It is important in this connection that roguing begin as early as possible in the spring in order to decrease the spread which is caused by aphids moving from one plant to another before the curl plants

are removed. Diseased plants should be dug, care being taken with reds to remove, so far as possible, all roots of the diseased plants. With reds, even the best of roguing will leave some of the diseased roots in the soil. These soon send up shoots which serve as a source of infection. Each rogued patch should be gone over several times for the removal of these shoots and any plants which may have been missed in the earlier roguings. Even if a plant has only one diseased cane, every shoot connected with that root system should be removed. In such plants, the curl virus is already well established in the root system by the time symptoms are visible on the canes and all parts of the plant will have curled leaves the following year even if the part which originally shows curl is removed.

The early removal of curl plants from fields of black raspberries will give control. However, if complete elimination of curl in red raspberry

Fig. 3.—A Cumberland plant affected by curl. The fruiting canes have been winter killed and the new canes are short and have crinkled leaves.

plantings is desired, and, if the hills are not distinctly separated, it is a good policy to remove one plant on each side of the diseased plant. The rogued area then should be kept free from sprouts during the remainder of the season. Too often, when only the diseased plant is removed, suckers from roots which have grown into the next hill are overlooked and, by the fol-

lowing season, the plants on each side of the rogued area have distinct symptoms of curl. The more thorough roguing requires time and careful work and involves the loss of a greater number of plants. In fields having very little curl, however, it is much more economical to use this added caution than to do a less efficient job of roguing and have the percentage of curl plants increase each year as it often does. In many red raspberry fields, curl may have too great a start to be economically controlled. In such cases, it will pay better to use the planting only for fruit, and to keep the field only so long as it pays a profit. It can then be discarded and a new planting started. In the first year, the new planting offers an opportunity, through the possibilities of more efficient roguing, to grow raspberries free or practically free from curl.

Burning the diseased plants in place as described for mosaics is equally effective for curl.

Mosaics

Distribution and Economic Importance. The mosaics are the most common of the virus diseases of raspberries. Mosaics also occur on blackberries and dewberries though they are rarely common enough to be of importance on these latter forms. The mosaics are the diseases which have been chiefly responsible for the "running-out" of many varieties of raspberries and they have been the cause of marked reductions in the yield of a number of others. They are found to some extent on all known varieties

Fig. 4.—Cuthbert plants showing mosaic and curl. At the time this picture was taken, the plant on the left was stunted by mosaic; the middle plant was healthy; the plant on the right was very much dwarfed by curl.

of raspberries and in all of the raspberry growing sections of the United States and Canada. As a rule mosaics are more common in reds than in blacks. Some of the red varieties have a high percentage of mosaic and are dwarfed considerably; others, although heavily infested, show very little injury.

Symptoms. There are several types of mosaic on raspberries. Some of these types have more or less well defined characteristics on a given variety. However, the symptoms of some of the mosaics vary considerably with the variety affected. The mosaics have in common the characteristic of mottling. Leaves are spotted and in extreme cases crinkled and otherwise deformed. The mottling varies from small yellowish spots to a condition in which the leaves have a few elevated green blisters surrounded by larger yellow areas.

Fig. 5.—The field shown above illustrates the effect of mosaic on the growth of plants. The rows to the left are healthy Kings; on the right, Latham plants having about 95 per cent mosaic are seen. The few healthy Latham plants were about the size of the King plants.

Yellowing of the foliage, extreme stunting of the plants, and death of the tips of the canes are symptoms more or less characteristic of individual forms of these troubles. Some of these symptoms can best be described in connection with a more detailed consideration of some of the different forms of mosaic.

The most destructive raspberry mosaic, so far as the individual affected plant is concerned, is one which occurs in virulent form on nearly all kinds of raspberries. It is one of the common mosaics found on the King, Latham, and Cuthbert varieties. On these varieties, leaves of the affected plants are mottled with yellow and green areas of various sizes and patterns often quite distinct in Cuthbert, but more commonly rather indefinite in King and Latham. Leaflets of affected plants are often slightly cupped. Diseased plants have a slightly yellowish cast and are somewhat stunted. Berries are smaller than those on healthy plants and inclined to crumble.

This type of disease causes much the same types of symptoms on purple cane varieties. It also attacks black varieties. Although more destructive to individual plants of blacks, it does not spread so rapidly as in reds and consequently, in the long run, causes less loss. First indication of infection

Fig. 6.—A Cuthbert leaf affected by a very virulent type of mosaic virus.

in blacks is usually a slight browning and bending of the tips of the new canes. The tips usually stop growth and sometimes die. The following season the new canes are rarely more than a foot high. The leaves are mottled and occur close together on the stem in a rosette, very little fruit is produced. The plants usually die the following winter. Symptoms, however, are not always so severe. In some fields, mosaic, though easily detected, causes less stunting on both reds and blacks. Whether this less severe form of mosaic is caused by the same virus as the above operating under different conditions or whether it is a modified product of the severe form or is distinct altogether, is not known. For practical purposes, however, this is probably not important except as it may throw light on the variations in symptoms encountered in raspberry plantings. Weather conditions have a

Fig. 7.—Mosaic such as that shown in Figure 6, transferred to a black raspberry plant results, the second year, in a plant similar to the one shown above. As a rule, it is not best to grow red raspberries close to black varieties.

marked influence on the appearance of symptoms. Warm weather has a tendency to cause a partial disappearance of mottling. This masking of mottling may be complete on the foliage produced during periods of relatively high temperatures, but symptoms will reappear on leaves which are produced when the temperature becomes lower. If mosaic is severe enough to cause dwarfing, the stunted condition, of course, will persist even though the leaves show no mottling.

Another type of mosaic found on reds, blacks and purples, is characterized by a still milder form of mottling which can be seen only on leaves which are produced when the temperature is very low. This mild form of mosaic

Fig. 8.—A tip of a cane of a black raspberry ten days after being inoculated with a relatively mild form of mosaic from a red variety. Growth is checked and dark brown spots are produced at the tips of the canes and on the leaf petioles.

is very common on black raspberries. Leaves of the fruiting canes show a very easily recognized pattern of mottling. Later in the season after the leaves of the fruiting canes have become yellow or have died, diseased plants are quite difficult to detect. Usually, however, on close inspection one or more zones of mottled leaves may be found on the new canes. These zones of leaves mark periods of low temperatures. The effect on the plant varies. In some cases there is considerable stunting but in most instances several years are required to cause much damage. Purple canes react to this disease in much the same way as do blacks. However, the disease is milder in its effects and requires much longer to cause reduction in yield. This mild mosaic also occurs on red varieties but it cannot be detected except on leaves produced at a low temperature and even on these, symptoms are so mild that they are often overlooked or attributed to some other cause. In some King, Latham, Viking and Cuthbert fields, nearly all of the plants have this form of mosaic. However, no noticeable reduction in yield has

occurred and on these forms the disease is doing very little if any immediate damage.

A third type of mosaic has been called yellow mosaic because of the distinct yellow cast of leaves of black raspberry plants affected by this disease. Leaves of Cumberland plants are slightly mottled and the leaflets are flat to spoon-shaped and distinctly yellow. Black raspberry plants are usually killed in the course of two or three years but in some instances diseased plants live for a much longer time. The same disease occurs on red raspberries and on dewberries. It is now known to be rather common on the King red raspberry in Berrien county and it also occurs in other parts of the state on Cuthbert and on the purple varieties Columbian and Cardinal. Leaflets of affected plants are yellow due chiefly to the fading of the tissue along the veins, and, in most cases, they are distinctly cupped. The plants are usually considerably stunted. Other mosaic viruses are so common in the plants of the King variety that, where yellow mosaic is found, it is usually in combination with the virus of some less destructive form of mosaic. A combination of this type usually causes the production of a greater amount of mottling and an additional decrease in the size of the plant. Dewberry plants are decidedly stunted and the leaves are very much mottled.

Spread of Mosaics. In some varieties of raspberries, mosaics spread quite rapidly and more slowly in others. King, Latham, and wild red raspberries are very susceptible. Spread is usually rapid within the variety and mosaics spread from these varieties to black raspberries to such an extent

Fig. 9.—A very mild form of mottling common on Viking, King, and Latham. This causes little direct injury to red varieties but is more severe on blacks.

that a rather high percentage of the plants in a field, growing alongside of red raspberries, may become diseased in a single season. The spread in Cuthberts and blacks and from these forms to other varieties is usually comparatively slow. On dewberries and blackberries the rate of spread is so low that mosaics have not become important on these forms. Mosaics are spread chiefly by a large, relatively long-legged aphid or plant louse

which is found in small numbers in nearly every raspberry field. Curiously enough the small aphid which carries the curl virus, does not seem to be an important factor in the transmission of mosaics. The large aphid occurs more abundantly on Kings, Lathams and wild red raspberries than it does on black varieties. The aphids prefer succulent rapidly growing tips as feeding places. They are usually found on the lower side of the very young leaves and sometimes on the stems themselves. However, sometimes they

Fig. 10.—A common type of mosaic mottling on black raspberries. This type of mosaic produces considerable dwarfing.

are found on the older leaves of any parts of the plant. When disturbed they often drop to other leaves or to the ground. Winged forms may be produced at almost any time during the season but at certain times they are more common than at others. These winged aphids fly for considerable distances. Winged forms have carried disease in controlled greenhouse experiments and field evidence indicates that these winged individuals are quite important in disease dissemination.

There is no evidence that pruning, harvesting or other cultural practices spread these diseases, or that they can be spread in any way during the dormant season.

Control. Sprays have given no satisfactory control of mosaics. Even those designed to decrease the aphid population and thus lessen the rate of spread have had very little noticeable effect. Even if spraying should be made effective, it would probably be much cheaper to obtain control by removing the infected plants. Control measures by roguing should be started

the first year the planting is set. This is especially true for red raspberries. During the first season aphids are not usually very numerous. As a rule one season is required for them to become well established in a new planting. Another distinct advantage of first year roguing lies in the fact that the plants are small and are easily pulled by hand leaving no root system which must be later grubbed out. After being pulled they should be carried to the end of the row and disposed of in such a way as to prevent migration of aphids back to the patch. Plantings having as high as thirty per cent mosaic have been rogued with excellent results. This type of roguing has been so effective that some of these plantings have had only two or three diseased plants per acre the second season. First year plantings should not only be rogued early but they should be rogued several times in an attempt to destroy all mosaic plants. In this connection it should be remembered that each diseased plant which is pulled the first season not only decreases spread, but also saves the digging of a larger plant the following season.

It is more difficult to control mosaics in old plantings. Red varieties are harder to free from mosaics than are blacks. However, if the percentage of mosaics is not too high, the more destructive types of mosaics can be controlled in the common commercial varieties. If roguing is done by digging, the diseased plants should be carried carefully from the field before they begin to wilt.

Fig. 11.—A Cumberland black raspberry leaf showing some of the characteristics of yellow mosaic. The leaf on the right is from a healthy plant. This mosaic also attacks dewberries and red raspberries.

Every reasonable precaution should be taken to avoid distributing through the field aphids which may be on the plants. The small aphid which transmits curl holds tenaciously to the leaves and very few drop in the process of digging and removal. In this respect, however, the aphid which transmits mosaics is a very different type of insect. If the rogued plants are not carefully handled, these insects drop to the ground during the process of roguing. The aphids which drop start crawling to the nearest plant. They move

rapidly and, in a large share of the cases, they find their way to a growing tip where they may transmit mosaic.

This danger of spreading aphids in the patches during the roguing process has led to attempts to find means for destroying the aphids before the plants are dug. Scorching the plants has seemed to be most practicable. This can be done very effectively by burning with gasoline or by use of a torch. If the plants are burned with gasoline, one operator usually sprinkles the plants while a second follows at a safe distance and lights the gasoline. Perhaps in many ways a more satisfactory method is the torch. There are on the market several very well designed torches which can be adapted to this work. Most of these torches burn kerosene and throw a flame from 16 to 25 inches long. After the diseased plants are marked, one operator can burn about 60 full grown black raspberry plants per hour. Torches of this type are too expensive for small plantings. It is probable, however, that they will find a place where roguing is done on a larger scale. It should be remembered that the primary object of burning is to kill the aphids. The plant roots are not killed, therefore, they should be dug before new shoots appear.

In whatever way the plants are removed, it is highly important that they be removed early in the season. Most of the infection takes place after the middle of June. Thus there is a period of a month or more in which to rogue plantings before the current seasons infections begin a serious spread of disease. Delay may mean that at the time of the first roguing, many plants are infected but have not had time to develop symptoms. These plants will serve as sources of infection throughout the remainder of the season, although the symptoms of disease may be very mild and the plants difficult to detect. Thus ridding the planting of mosaic will be delayed and may be defeated altogether.

Streak

Streak has also been called blue-stem and rosette. It is very destructive in black raspberries but is not known to occur on reds. The disease is very common in some parts of Ohio where, in certain sections, whole fields have been affected. It is less common in Michigan and, as yet, has not spread very rapidly or widely. It occurs, however, in a number of fields.

Symptoms. The terms streak, blue-stem, and rosette are descriptive of certain phases of this trouble. Diseased plants are most readily detected in the middle of the summer or later. The leaves of affected plants are a shade deeper green than normal. They also have a tendency to curl slightly at the edges and the leaflets twist in such a manner as to bring the lower side of the tips uppermost. This twisting is especially noticeable in the leaflets of the tips of the first year canes. Such a tip is shown in Figure 12, a. Dry weather sometimes produces a similar condition. At times, there is a faint pattern of rather coarse mottling but this is not a constant characteristic. In most cases, the new canes are striped with dark-reddish streaks. (Fig. 12, b.) These vary from a sixteenth to an eighth of an inch in width. The length also varies. Sometimes, the stripes are close together, and, occasionally, they are confluent producing a solid bluish-red cane. Diseased plants are stunted and usually die after four or five years.

Spread. Streak is carried in nursery stock and spreads also from plant to plant in the field. The rate of spread varies considerably, but, under Michigan conditions, it has never been known to be very rapid. In

some other parts of the United States, conditions for dissemination have apparently been more favorable and the disease is more serious. Because of the occurrence of new infection in the vicinity of streak plants, it is believed that this disease is spread by aphids in much the same way as curl and the mosaics are carried from one plant to another. However, neither the small aphid which carries curl nor the large aphid which transmits mosaics, has been definitely shown to be responsible for streak transmission. There are many other insects which feed on raspberries, and, in time, it may be found that one of these is the disseminating agent.

Fig. 12.—Streak on Cumberland raspberry. a. Tip of an affected cane showing characteristic bending of the leaves. b. Cane showing striping. c. Cane from a healthy plant.

Control. The only known practical control measure for this disease is roguing. This is best carried out in the same way as described for mosaics, except that a greater amount of roguing must, of necessity, be done later in the season on account of the later appearance of symptoms of streak.

BACTERIAL AND FUNGOUS DISEASES

Crown Gall

Under Michigan conditions, crown gall, root gall, root knot, or stem gall, as this disease is variously called, is one of the most destructive troubles of raspberries. In the light sandy soils of southwestern Michigan and other parts of the state, it develops abundantly on the roots of a number of red varieties and on the crowns and canes of blacks and purples. Crown gall also attacks the blackberry, dewberry, apple, peach, tomato, sugar beet, and many other kinds of plants.

Symptoms. Crown gall occurs typically in the form of galls or knots, often near the crown of the plant, but, frequently, on the canes and roots. First indication of disease is a slight swelling of the affected part. These enlargements increase in size rather rapidly and sometimes grow to be two or more inches in diameter. Usually, however, galls on raspberries are somewhat smaller. At first they are white and inclined to be soft, but, as the galls approach full size, they become darker and more woody. The surface is rather rough, warty, or irregular. Soon after the galls are mature they begin to decay and are invaded by many kinds of molds and insects.

Gall development on the stems, crowns, or roots weakens the plants to a considerable extent. The galls themselves require food for growth. This is taken from the rest of the plant. Galls also, because of the abnormal structure, interfere with the movement of water and food materials from one part of the plant to another. This leads to a stunting of all or a part of the plant depending on the location and extent of infection. The severity of the injury also depends, to a considerable extent, on the variety attacked. Root and crown attacks are more destructive than cane infections. In general, black raspberries have root systems which are seldom severely injured. The severe attacks occur in the region of the crown and on the fruiting canes. On the latter, warty excrescences break out on the main stem and laterals and around the base of the fruiting shoots. This leads to drying of the fruit and to "seedy" berries. In addition to the definite knots on the fruiting canes, which are believed to be caused by the crown gall bacterium, there are sometimes found many smaller excrescences or small galls which break through the outer bark singly or in masses. These smaller galls in many cases are believed to be due to callus formation following injuries of various kinds. What percentage of gall formation is of this type has not been determined. Fields having an abundant production of galls on the fruiting canes one season may have fewer galls the following season. Galls are not often found on the new canes, however, galls are sometimes so abundant in the crown in the region where buds for new canes are produced, that no new canes are formed. In such cases, the old canes produce a crop of fruit, but, after harvest, the entire plant dies.

On red raspberries, gall is found more commonly on the roots and rarely injures the canes by direct attack. Even in badly infested fields,

galls may be very rare on the above-ground parts. However, a badly infested root system produces weak stunted canes and markedly decreases the yield of fruit.

In the case of purple canes, both roots and the tops are to a certain extent susceptible to severe infection. The crown, however, seems to be the region of greatest occurrence of gall. As in the blackcaps, this type of attack prevents the formation of the normal number of new shoots and plants are lost each season after fruiting. Figure 14 illustrates the way in which plants are killed. The Columbian is quite susceptible to this type of injury.

Fig. 13.—Crown gall on a Cuthbert raspberry plant. This plant came from a bundle of nursery stock containing gall. At the time of planting it showed no sign of infection. By the middle of the first season, however, galls had developed.

Cause. Crown gall is caused by a small motile bacterium, *Bacterium tumefaciens,* which is too small to be seen with the unaided eye. This germ invades the tissues of the plant and causes such rapid growth that normal supporting and conducting tissues are not produced, hence the plant is injured and the galls themselves are short lived. The bacteria live in the galls and are liberated in the soil as the galls disintegrate. The bacteria may live in decayed material in the soil for a considerable period causing reinfection at favorable times. New infection takes

Fig. 14.—A common effect of crown gall on the purple variety, Columbian. This plant produced a crop of fruit but no new canes were formed. The reason for this is illustrated on the root system shown on the right. The region which normally gives rise to buds for new canes is occupied by galls. Plants of this type die soon after fruiting.

place through wounds. This method of infection partially accounts for the susceptibility of red raspberries to root attack and for the galls which are formed on the canes of black raspberries. Red raspberries produce roots in great abundance. These are often injured in cultivating and other injuries are produced in cutting off the numerous canes which start between rows. The large number of wounds formed in these ways offers ample opportunity for heavy infection. Black raspberries are more susceptible to serious stem attacks because of wounds produced by spines and by breaking of the bark at the base of the fruiting shoots. The roots are not so superficial nor so widespread as the roots of reds, consequently, they are not so subject to injury and are affected to a lesser degree by crown gall.

Control. After plants are started in the field there is no practical way for preventing gall development. For this reason control measures must necessarily be confined largely to the planting of gall-free stock

on soil which contains few or none of the gall producing bacteria. Gall-free plants are difficult to secure, but plants relatively free from gall can, in most cases, be obtained. The grower's best plants come usually from young plantings on his own farm. In young plantings, the disease has usually not spread through the soil from the older parts to such an extent that the season's crop of new plants is heavily in-

Fig. 15—In some fields, galls of this type are common on the fruiting canes of black raspberry. They are usually located around the base of the fruiting shoot.

fested. This is especially true of black and purple raspberries. These are tipped at a distance from the crown and have less chance of coming in contact with gall bacteria from the older parts of the plant. Tips from one or two year old plantings, when dug and transplanted soon afterward, usually give good results. Plants which come from old gall-infested fields, even if they are planted soon after being dug, usually have considerable gall. However, the percentage of diseased plants is usually much less than the percentage of infection in the mother plants. Plants which have been heeled in or which have been held in cold storage and wet down several times, although they may have few visible galls when planted in the field, have been known to become severely diseased often before the end of the first season. Apparently, in such cases, the bacteria are washed from the few galls which may be in the bundles and find their way into wounds where they become established but do not produce visible swellings until after planting.

It is not known to what extent infection in new plantings takes place from the soil. However, it is not a good practice to plant raspberries after raspberries, blackberries, or dewberries. Soils which have grown such crops as clover, corn or beans for two or three years should be relatively free from the crown gall bacterium.

Anthracnose

Anthracnose is one of the most important fungous diseases of the raspberry. This disease is found to some extent in nearly all of the raspberry plantings of this and other states. Black raspberries are injured most. Dewberries are also severely affected. Blackberries and purple and red raspberries are not often severely damaged. All of the commercial varieties of black raspberries such as Cumberland, Plum Farmer, Gregg, and Kansas are quite susceptible. The black variety Quillan, grown to some extent in Illinois, is considered very resistant.

Symptoms. Spots caused by anthracnose usually begin to appear on the stems in the spring by the time the new canes are six inches high. The spots are at first small and reddish brown in color. They enlarge as the canes grow, and reach a size of something less than a quarter of an inch in diameter. In this stage, the spots are easily recognized and quite characteristic. They are more or less round and have a white, slightly sunken center surrounded by a red ring. The spots are sometimes so numerous that individual spots run together covering a considerable portion of the surface of the cane. The same type of spot occurs on the fruiting shoots of the fruiting canes.

Spots are usually unevenly distributed along the length of the cane. This is due to the fact that only the very young and succulent parts are susceptible to infection and to the necessity for rains or heavy dews for spore germination. During dry periods portions of the canes grow and become too woody to be attacked by anthracnose. Thus rainy periods are marked on the canes by anthracnose spots while growth produced during dry weather is relatively free from disease. In general, dry seasons are very unfavorable for anthracnose development.

On the leaves, small yellowish spots less than a sixteenth of an inch in diameter, are the first signs of disease. These spots turn

red as they enlarge somewhat and ultimately consist of a light colored spot surrounded by a red ring. The main veins and leaf petioles may be attacked. Lesions, in a general way, are similar to those on the canes. They differ, however, in being smaller and more elongated. Leaf attacks are usually rather limited and rarely cause severe damage.

Anthracnose injures the fruit by direct attack as well as indirectly by causing spots on the fruit pedicels and on other parts of the plant. Attacks on the fruits cause certain divisions of the berries to fail to mature. In more severe cases, the entire fruit dries before ripening. Dried berries in clusters of normal fruits are usually caused by anthracnose. Prolonged rains just before the blossom clusters begin to open bring about severe spotting of the fruit pedicels. These spots are small but they interfere materially with the movement of food and water to the berries and cause them to be small and dry. In cases of severe attack, the fruits do not mature.

Fig. 16.—Anthracnose spots on Cumberland black raspberry canes. The cane on the left shows spots as they appear on the young canes during the middle of the season. The cane on the right shows the early spring stage on the fruiting canes.

Cause. Anthracnose is caused by a fungus, *Plectodiscella veneta,* which lives in the lesions produced on the stems, leaves, and fruits. The fungous threads grow between the cells of the affected tissue. Near the surface of the spots they form little cushions on which spores are

produced. These spores are liberated on the surface of the canes in great numbers during rainy periods throughout the season. They are spattered in small drops of water from the old lesions to the growing tips of canes and to other succulent parts where they germinate and produce infection. During the winter, the anthracnose fungus lives in the spots on the canes. In the spring, it matures two types of spore producing bodies, the one which has just been described and a second

Fig. 17.—Anthracnose spots on a red raspberry leaf.

type which is found around the edges of the spots and is indicated on the surface of the cane only by slight elevations. This second type of fruiting body, an ascocarp, is usually not so abundant as the first. It is more or less oval in shape and contains its spores in small sacs. These spores, during rains, are expelled by force and may be carried in the wind for considerable distances. These spring spores are probably important in spreading disease from wild patches into new plantings. The summer spores, on the other hand, are not blown in the wind except in rain drops and usually do not spread disease to parts more than a few feet from the spots in which they are produced. Thus the fungus is admirably equipped for survival, the spring spore carrying disease from plant to plant early in the season and the summer spore being capable of forming many generations in the course of a season and increasing the infestation on the plant on which infection is first produced.

Control. Anthracnose is usually not serious enough on red and purple raspberries to require a well planned control program. On black varieties, however, the disease is more serious and measures must be taken to hold it in check if the best results in raspberry production are to be secured. The most satisfactory control is obtained by a combination of sanitation and spraying. It is well known that anthracnose is carried to the new plantings on the so-called "tails" of the young tips. In setting new plants, often the old canes are left projecting into the air and attached to the roots. These old canes usually have anthracnose present on some part, as shown in Figure 18. Spores spatter from these spots to the new shoots which are produced. In this manner

Fig. 18.—Anthracnose spots on the "tail" of a black raspberry tip. If this old cane is left above ground after planting, the new shoots soon become affected by anthracnose.

nearly all of the plants in a new field may become heavily infected during the first season. If the old canes are removed and the tips buried completely at planting time, the new shoots will grow up relativly free from anthracnose and the disease will be much more easily controlled in succeeding years by sprays. To secure best results, planting should be done early, only vigorous tips should be used, and the tips should be removed directly from the mother plants to the new planting. Weak tips or tips which have started growth in storage or in transit give a poorer stand when the old canes are removed than when these parts are left. If fresh vigorous plants are used, the stand is not affected to any appreciable extent by removal of the old parts. If planting is too much delayed, new shoots may be produced and infected before transplanting takes place.

In all Michigan black raspberry plantings, anthracnose can be controlled, in most seasons, by the application of two sprays. If the field has been started with a minimum amount of anthracnose, one spray in the delayed dormant applied each season may be sufficient. Sprays may be applied as follows:

1. When the buds begin to break. Use 5 to 10 gallons of liquid lime sulphur and add enough water to make 100 gallons.
2. About one week before the blossoms open. Use Bordeaux mixture 4-8-100. Two gallons of liquid lime sulphur with enough water added to make 100 gallons of the mixture, applied at this time, will also control anthracnose but there is more danger of burning the leaves than with Bordeaux. This schedule will also control anthracnose on dewberries.

It is not safe to spray raspberries after the blossom period. Sprays later in the season sometimes produce severe injury.

Orange Rust

Orange rust is found in many parts of the United States, but probably nowhere is it more destructive than in southwestern Michigan. In this region, the roadsides and waste places have grown up, in many cases, to raspberries, blackberries, and dewberries which are commonly infested with rust. From these sources rust spreads to the commercial fields where, in some cases, it seems to continue the spread and attacks a large number of plants in a few years. Rather large fields not more than six years old have been noted in which 95 per cent of the plants were attacked by this disease. Fields having 10 per cent of the plants rusted are more or less common and smaller numbers of rusted plants occur in a considerable percentage of the fields of black raspberries and blackberries. Since rusted plants are of little or no value the loss due to this disease is of considerable importance.

As has been indicated, blackberries, dewberries, and black raspberries are susceptible to rust. Some varieties, however, are injured more than others. Of the black raspberries, Cumberland seems to be slightly more susceptible than Kansas and Plum Farmer. The Lucretia dewberry is very resistant and the Eldorado blackberry is more resistant than the varieties Kittatinny, Snyder, Mersereau, and Blower. The disease is not known to occur on red raspberries. It occurs in purples, but it is extremely rare in varieties of this kind of raspberry.

Symptoms. Rusted plants are easily located in the spring soon after the leaves have started to expand. Diseased plants are quite conspicuous until about the first of July. During the greater part of June, rusted plants may be seen for a considerable distance. Badly infested fields are seen as orange colored spots on the landscape. Diseased plants are decidedly stunted but produce an abnormally large number of new canes. Sometimes thirty or forty canes appear in a single hill. (Fig. 19.) These canes are spindling and usually devoid of spines. In some cases only a portion of the plant may be affected. In such plants, the unaffected canes behave in a normal way. Rusted plants or rusted portions of plants, very rarely fruit and, in most cases, do not form blos-

Fig. 19.—A rusted plant from a field which had been abandoned because of orange rust. Note the small leaves and the large number of canes.

soms. The leaves of both the new and the fruiting canes are small and oddly shaped. Soon after the leaves begin to unfold, small glistening bodies begin to appear on the upper side. These are followed, in the course of a few days, by the appearance of a second type of fruiting body which is more abundant on the lower side of the leaf. These latter structures first appear as light colored blisters with irregular outlines. These blisters soon take on an orange color, break open, and

release thousands of orange colored spores. In this stage, nearly the whole plant may seem to have an orange color.

Frequently rusted plants are covered by a white mealy growth. This is another fungus, a powdery mildew, which attacks healthy plants of many varieties of raspberries but which finds conditions very favorable for luxuriant growth on plants which have been weakened by rust.

After about the first of July, rusted leaves begin to die and drop. The leaves which are produced after this time are quite normal in shape and general appearance and do not show symptoms of rust. This may lead to the mistaken belief that the plant has recovered from the disease. Such plants, however, very rarely recover but continue to produce a new crop of rust spores each season so long as they live.

Fig. 20.—A healthy (left) and a rusted (right) Cumberland black raspberry plant. No fruit was produced on the rusted plant.

Cause. Orange rust may be caused by either one of two species of rust fungi. One of these is a so-called short cycle rust, *Kunkelia nitens*, and the other a long cycle rust, *Gymnoconia interstitialis*. The latter is responsible for nearly all of the raspberry rust and the former is more common on blackberries and dewberries. The fungous threads of each of these forms live throughout the year between the cells in the bark and wood of the stems, crowns, and roots of the affected plants. Each season, at the time shoot and root growth begin, the fungus grows into the new parts and keeps pace with their development. Thus, it grows into the young leaves, after which, the first external signs of the fungus itself are manifest in the form of small fruiting bodies (pycnia). These are more abundant on the upper side of the leaf. The orange colored structures which are formed about two weeks later on the lower side

of the leaf are irregular cups (aecia) filled with spores (aeciospores). In the case of the long cycle rust, these spores are carried to the leaves where they germinate and produce infections which soon result in small yellow spots. On the lower side of the leaf, in the center of these spots, dark masses appear. These are composed of clusters of another type of spore(teliospore). These spores germinate and produce still another kind of spore (sporidium) which finds its way to some rapidly growing shoot, perhaps near the crown of some plant, where infection again takes place. This time the rust fungus establishes itself in intimate contact with the raspberry, dewberry, or blackberry tissues, as the case may be, where it remains firmly established during the rest of the life of the plant. The short cycle rust, which is common on blackberries and dewberries and only occasionally attacks black raspberries, produces secondary spores (sporidia) directly from the orange spores. These, in turn, are carried by the wind and produce systemic infection in other plants.

Control. The surest and most economical control measure for orange rust in raspberries, as well as in blackberries and dewberries, consists in removing the rusted plants early in the season. Fields of susceptible varieties of all ages should be watched for the appearance of diseased plants. Since orange rust may be carried in nursery stock, even first

Fig. 21.—Leaves from a rusted Cumberland black raspberry plant showing the spore cups or aecia.

year plantings should be watched and rusted plants removed if they appear. In all plantings, it is very important that rusted plants be dug before the orange spores begin to be shed by the leaves. If the elimination of these plants is delayed, there is danger of considerable summer infection which may lead to many more rusted plants the following season. If the rusted plants are dug early, it is not necessary to remove them from the patch immediately or to burn them. The rust

fungus dies almost as soon as the plant in which it is growing and consequently there is very little danger of rust spread from dead plants.

If at all feasible, rusted wild blackberries, dewberries, and raspberries growing in the vicinity of the planting should be destroyed in order to prevent infection from outside sources.

Wilt

Wilt was first discovered on raspberries in the Puget Sound district of Washington about 1904. For a time it was called blue-stem. It was not until several years later that the trouble was recognized in the eastern part of the United States though it was probably present in many places. The damage caused by it was probably attributed to cane blight or to other causes. It is now known to attack nearly all varieties of raspberries and in recent years, it has caused a certain amount of damage in eastern United States and Canada. Wilt has been found in several fields in Michigan. Cuthberts have been injured to a slight extent and Cumberlands, in some cases, have been severely damaged. In one Cumberland planting, more than 50 per cent of the plants were lost in three years. Another field of about three acres was taken out the year after planting, because of the large number of plants destroyed by wilt. Smaller numbers of plants have been killed in other fields.

Symptoms. The term wilt is more or less descriptive of the later stages of this disease. Blueing of the stems and death of the plants are other characteristics. The disease sometimes works very slowly, and, usually, from one to three years are required to kill a plant. First symptoms usually appear after the middle of the season. During August, leaves of affected black raspberry plants become pale and the tips of the canes grow slowly. This pale condition of the foliage persists through the warmer part of the summer. Later in the season, as the weather becomes cooler, the plants often start growing more rapidly, lose some of their yellow color, and seem to partially recover. The second season symptoms are more marked. The lower leaves roll, turn yellow or brown, and droop or fall from the canes. Soon the same symptoms are produced on other leaves. The cane tips stop growth and wilt and the cane turns a dark blue color. This usually involves the death of the entire plant. A plant in the last stages of disease is shown in Figure 22. In general, the symptoms on red raspberries are similar to those on blacks, but, as a rule, the results are less severe. The entire hill may be affected, but more often the disease is confined to a few canes. Leaves droop and die as described above, often leaving only a tuft of leaves at the tip of the cane. Some of the canes are more severely affected on one side than on the other. The severely injured side is often marked by a broad blue stripe and wilted yellow leaves. In reds, the disease is worse some seasons than in others and many plants seem to partially or completely recover.

Cause. Wilt is caused by a fungus, *Verticillium ovatum,* which is capable of living for a considerable time in the decaying organic matter of the soil. This fungus grows into the roots of the raspberry plant, invades the water conducting tubes of the roots, crown, and stems, and interferes directly or indirectly with the movement of water from

the roots to the tops. After the plant is killed, the fungus lives in the dead stems and roots for a considerable time. How long it will remain alive in the soil is not known. It seems, however, to persist at least from one season to the next in soil from which wilted raspberry plants have been removed. The fungus is spread from one place to another by means of trash and probably also by means of spores which are produced in great numbers. It is also capable of growing for short distances through the soil.

Fig. 22.—A wilted black raspberry plant as it appeared the latter part of August.

Factors Influencing Wilt Production. Plants are more subject to wilt during warm weather than during cool periods. The wilt fungus makes its most rapid growth at temperatures between 80 and 90 degrees. This also seems to be a very favorable temperature for wilt production. Wilt is said to be more destructive in fields which have grown potatoes, tomatoes, or egg plants in years preceding the planting of raspberries. This has not been true, however, in the case of diseased fields which have been observed in this state. One of the most severe attacks was found in a field in which muskmelons had been grown for several successive years before it had been planted to raspberries. Another wilt field was planted after peaches and other nursery stock. It has been noted, however, that fields which have shown most wilt have been set from plants which had been shipped

from a distance or had been kept in storage for a time. Plants moved from one field to another with a minimum of root injury have shown little or no wilt. The wilt fungus gives every evidence of being rather common in nature. It is entirely possible that this organism is present in many lots of plants but multiples and produces infection on a large scale only when the roots of young plants are partially rotted and the plants considerably weakened from being in storage too long. It is believed probable that in most of the wilt fields found in the state up to the present time, the plants were infected before setting. However, in view of the experiences in other raspberry sections, it seems reasonable to expect that we may encounter wilt which may come from refuse of such crops as potatoes, tomatoes, and egg plant, inasmuch as the same wilt disease is known to attack these crops.

Control. It is necessary, for the most part, to confine control measures for wilt to the prevention of disease by certain sanitary measures. It is unsafe to plant raspberries following potato or tomato crops which have had this type of wilt. It is advisable to, so far as possible, avoid long continued storage of nursery stock in order to reduce the chances of infection before planting.

After wilt becomes established in a field, very little can be done towards control. In black raspberries, the disease seems to spread slowly from plant to plant along the row and from row to row. Removing the diseased plants as soon as they can be detected may in some cases check spread somewhat but this method does not often stop spread entirely. Black raspberry tips planted where wilted plants had recently been removed have in most cases succumbed to attack. Red raspberries are apparently more resistant and in some instances seem to recover. Plants showing distinct early symptoms of disease one season may show very little or no wilt symptoms the following year. Cool weather seems to favor recovery.

Cane Blight

Cane blight attacks all of the important varieties of raspberries and is found in all of the chief raspberry sections of the United States and Canada. The Cumberland and the Cuthbert seem to be injured more than other varieties, probably because they are grown more extensively. The purple canes as a group seem to be more resistant. Cane blight, however, is not so destructive as several of the other raspberry diseases. In Michigan, it is usually a relatively minor disease. Only in rare cases has it been known to cause any considerable amount of loss. In fact, the importance of this disease has probably been much overestimated. Death of canes due to winter injury and other causes has, in many cases, been attributed to cane blight. This has probably come about because of the fact that the cane blight fungus grows readily on any dead cane. When canes are killed during the winter or early spring, usually, one can find the cane blight fungus growing on some of the parts at sometime during the following summer. Under such circumstances, it is sometimes difficult to determine accurately the primary cause of the injury. It is probable that in many such cases the cane blight disease has received more than its rightful share of credit for the damage produced.

Symptoms. The most characteristic symptoms of cane blight make their appearance sometime between blossoming and the period of fruit ripening. The disease typically attacks one or more of the fruiting canes but rarely kills the entire plant. The affected cane begins to wilt, the leaves droop and turn brown, the berries become dry, and a part or all of the cane dies (Fig. 23). On each diseased cane, there are one or more slightly faded areas, varying from one to several inches in length and covered by a smoky colored growth and studded with small dark colored bodies (Fig. 24). These regions are cankered areas caused by direct attack of the cane blight fungus. All parts above such

Fig. 23.—Cane blight. The fruiting canes are killed before the fruit ripens; the new canes usually are not injured. (Photo. W. C. Dutton.)

cankers die. The amount of killing, therefore, depends on the number and location of these cankers. If a canker is located on a fruiting lateral, only a small part of the cane may die; if the canker is on the main cane, as it often is, the entire cane may be killed.

Cause. The cause of cane blight is a common and rather well distributed fungus, *Leptosphaeria coniothyrium*. The threads of this fungus grow through the wood and bark of the affected raspberry canes and produce fruiting bodies, called pycnidia, which are visible on the surface of the cankers. These fruiting bodies are mostly imbedded in the bark. They are more or less spherical and are filled by large numbers of spores. After these spores are ripe, which is usually a short

time after the canes are killed, they are pushed out through an opening in the top of the pycnidium to the surface of the cane. They often come out in tendrils and spread over the surface of the bark. These spores are spattered and carried by wind blown rain and by insects to

Fig. 24.—A blight canker on a black raspberry cane. Note the small fruiting bodies of the cane blight fungus.

other canes where they produce infection. The tubes from the germinating spores enter through wounds and possibly through other avenues. Frequently, wounds caused by the snowy tree-cricket are centers of blight cankers. After the fungus has gained entrance to the first year canes, it apparently grows slowly and causes no noticeable injury the first year. The second year, however, the fungus invasion continues and the fruiting canes are killed as described above.

As is true for other fungous diseases, rainy weather is conducive to infection. After the fungus has entered the cane, however, it continues to grow regardless of whether the weather is wet or dry. Since, in the case of cane blight, infection often takes place one season and blighting occurs the following season, the weather relations are somewhat more complex than with some of the other fungous diseases. The cane blight fungus grows best at a rather high temperature. This relation probably accounts for the slow progress of the disease in the fall and early spring and the rapid development the latter part of June and through July.

Control. No very satisfactory spray measures have been developed for the control of this trouble. The anthracnose sprays are probably of little benefit since the great majority of infection probably takes place a considerable time after the last one of these sprays is applied. The extreme susceptibility of raspberry foliage to spray injury has discouraged spray applications later in the season when they would be expected to be more effective. Fortunately, the disease is rarely severe enough to justify spray applications even if it could be controlled in this way. The disease can to a certain extent be held in check by cutting out and burning affected canes as soon as they begin to show signs of disease. This practice eliminates a considerable quantity of the fungus which would otherwise produce fruiting bodies and spores for further spread. Spores are usually not discharged until after a part or all of the affected cane is killed, hence, infection from spores on these canes usually does not occur until after the grower has had an opportunity to eliminate a large share of this source of danger.

Spur Blight

Spur blight is a fungous disease which is now known to be distributed over the greater part of the United States and Canada. It has been reported as serious in some parts of Colorado, but, in most parts of the United States, it is of less importance and is considered one of the minor diseases. Red varieties are, as a rule, susceptible. Black and purple forms are rarely attacked. Of the reds, the June, and Marlboro are relatively susceptible; the King, Cuthbert, and Herbert are more resistant.

Symptoms. The results of spur blight attack can be found either on the old canes or on the new at almost any season of the year. On the young canes, symptoms begin to appear by the early part of July. Dark reddish areas, as shown in Figure 26 a, develop on the lower portions of the canes at the base of the leaves and around the buds in the axils of these leaves. Usually, the leaf petioles are so injured that the leaves droop and die. The disease spreads in the bark around the buds.

The darkened areas are sometimes an inch to two inches long and extend completely around the cane. Often, lesions coalesce and the entire lower portion of the cane, for a foot or more, has a dark reddish color and is devoid of living leaves. In the fall, the dark reddish areas begin to bleach. In the spring, the diseased areas have a light grayish color. Each canker is studded with small, but easily visible, black fruit-

Fig. 25.—Spur blight on the Marlboro variety.

ing bodies or perithecia. This stage is shown in Figure 26, b, c, and d. Few fruiting laterals are produced from the cankered region. If attacks have been confined to the lower half of the cane, as is often the case, little damage occurs. However, if the buds on the upper half of the cane have been affected, the fruiting cane produces only a limited number of fruiting shoots and as a result, the yield of fruit is materially decreased.

Cause. In the winter and early spring, the fruiting bodies of the fungus, *Mycosphaerella rubina*, which causes spur blight, are quite conspicuous. They are located immediately below the epidermis of the grayish spots. These bodies, in an immature condition, carry the fungus through the winter. In the spring, each fruiting body develops a number of sacs or asci in which spores, called ascospores, are formed. These spores are liberated during rains in the spring and cause infection on the new canes. The fungus threads grow into the bark of the canes penetrating, in the earlier stages, to only a short distance. A considerable thickness of green bark can usually be found below the outer discolored portions. In the outer discolored parts of the bark, the fungus produces a second type of fruiting body, a pycnidium, in which spores are formed. These summer spores are available throughout the greater part of the growing season and continue the spread of disease to uninfected parts of the canes.

Fig. 26.—Spur blight. The cane on the left, a, shows the type of spot produced during the first season of infection. The three canes on the right, b, c, and d, show blight spots as they appear on the fruiting canes early in the spring. Note the fungous fruiting bodies or perithecia.

Control. It has been shown that spur blight can be controlled by certain kinds of sprays. Spray schedules have been developed in certain parts of the United States in which the disease has been more serious than in Michigan. In this state it has never been known to

have been prevalent enough to justify a regular spray application. Unless it becomes more serious than it is now known to be, it is believed that the application of sprays will rarely be necessary.

Powdery Mildew

Mildew has only recently become of importance on raspberries. It occurs on wild reds and on blacks in most parts of the state, but these forms are so resistant that the mildew disease is rarely called to attention. Likewise most of the commercial varieties are quite resistant. None of the black forms such as Cumberland and Plum Farmer are

Fig. 27.—Mildew on a leaf of the purple cane variety, Cardinal.

seriously affected. The Cuthbert is also resistant. The King is more susceptible but is not greatly damaged. The varieties which are most susceptible and the only varieties which have been seriously injured are the purple variety Cardinal and the red variety Latham. The Cardinal is of little economic importance as a variety, but the Latham is being grown more widely each year and the continued popularity of this variety will probably cause mildew to become one of the important enemies of the raspberry wherever the Latham is grown. The disease is of no commercial importance on blackberries or dewberries.

Symptoms. Primarily, mildew attacks the leaves but it is also quite often found on the more succulent parts of the stems. Slight mildew attacks cause irregular light green or yellow blotches on the top side of the leaves. Just opposite, on the lower side, the leaf surface is

usually covered by a mealy growth of fungus. In some cases, however, the fungus is seen with difficulty if at all and the spots have a water-soaked appearance. Spots vary in size from very small to an area as large as the leaflet. Leaves having a number of small or medium size spots are mottled in much the same way as leaves affected by mosaic (Fig. 27). If the entire leaf is covered by mildew, as happens frequently with Cardinal and Latham, the leaflets are small and often distorted and curled upward at the edges (Fig. 28). Tips having leaves of this type are usually much dwarfed. The canes grow very slowly and frequently are not more than two-thirds as tall as unaffected canes. Sometimes the canes continue to grow but only very small leaves are formed. This gives rise to a condition which is sometimes called "rat-tail." Usually, the canes as well as the leaves are covered by a visible mildew growth and the canes have a small diameter. The small leaves have a water-soaked appearance and the top side may be covered with a mealy coating of spores which have dropped from other parts of the

Fig. 28.—Mildew on the tip of a cane of the Cardinal variety. Leaves are dwarfed and the tip is beginning a type of "rat-tail" growth.

cane. After the middle of the season, tips of mildewed canes sometimes die. This association of dead cane tips with severe mildew infestations has been noted in quite a number of fields. Whether death was caused by mildew alone or whether other influences such as dry weather or other diseases were factors, remains to be determined.

Cause. Raspberry mildew is caused by one of the true powdery mildew fungi, *Sphaerotheca humuli*. This fungus has not as yet been very carefully studied and many things about its life history and its effect on the raspberry plant remain to be learned. This mildew, like the mildew of grape, cherry, and other plants, is largely superficial. The mildew fungus is readily visible as a white growth over the surface of the leaf. A hand lens reveals many small branched threads in close contact with the leaf surface. These threads feed on the raspberry leaf by sending sucker-like branches into the epidermal cells of the leaf. This feeding and the resultant irritation cause the curling and dwarfing which is characteristic of the leaves of diseased plants. From the threads, short upright stalks which cut off spores are produced. Spores are liberated in great numbers. They are blown in the wind for considerable distances. When they fall on a raspberry leaf, they may germinate and start a new mildew spot. Early, each spring, the mildew fungus appears on the leaves of both the fruiting and the new canes, and continues to spread throughout the season. Warm, cloudy weather with heavy dews or prolonged rains favor spread.

Control. Control measures for mildew on the common varieties of raspberries grown in this state have never been necessary. If a very susceptible variety such as the Latham should become extensively grown, it is probable that mildew would become serious enough to justify attempts to control the disease. Powdery mildews in general are controlled by the application of sulphur sprays or sulphur dusts. However, sprays for raspberry mildew have not been sufficiently tested. It is probable that the two sprays recommended for anthracnose are of considerable value. If sprays are applied later in the season, due consideration should be given to the injurious influences which sulphur sprays may have on the foliage of the raspberry plant.

Leaf Spot

Raspberries, dewberries, and blackberries are attacked by a rather common type of leaf spot. Dewberries are injured more than raspberries or blackberries. On dewberries, the disease is often very prevalent and frequently is confused with anthracnose. All varieties of raspberries are susceptible but few are injured to any considerable extent. The King is more susceptible than any of the other common varieties grown in the state.

Symptoms. Leaf spot makes its appearance quite early in the spring. Dark reddish spots may appear on the leaves in considerable numbers. These spots are round and each spot may be seen from either side of the leaf. They are usually about an eighth of an inch in diameter and rather uniform in shape and size (Fig. 29). As the spots become older, they bleach to a very light color but, usually, they are surrounded by a red ring. Small black dots may appear in the spots. Sometimes the

central portions of the spots pull away from the surrounding tissue, and drop out giving a shot-hole condition. Spots are sometimes very numerous, in which case many of them coalesce. Whole leaflets may be killed directly in this way, but, more frequently, the attack is heavier on one edge or one-half than the other and only a portion of the leaflet is killed. Heavy attacks also may cause leaves to turn yellow and drop.

Fig. 29.—Leaf spot on a black raspberry leaf.

The leaf spot disease also attacks the stems but causes little damage to the canes of raspberries or blackberries. It is more common on the stems of dewberries and sometimes causes considerable spotting and cracking. The chief damage, however, to both dewberries and raspberries consists in the general weakening of the plant through loss of leaf surface.

Cause. The fungus, *Mycosphaerella rubi,* which causes raspberry leaf spot is similar to a number of other leaf spotting fungi. The summer fruiting bodies of this fungus may be seen as small black dots called pycnidia, scattered through the dead tissue in the central portions of the spots. These pycnidia are filled with spores which find their way to the leaf surface and are then scattered to other portions of the plant or to other plants where they germinate producing slender germ tubes which enter the tissues of the leaf and branch into threads which kill the invaded portions of the leaf, thus causing more leaf spotting. Several generations are produced in a single season and

spores are available to be spread during each rainy period. The fungus lives through the winter on the diseased leaves on the ground. In the spring, it matures a second type of fruiting body, called a perithecium, in which spores called ascospores are produced. These in the spring are discharged into the air to begin the seasons series of infections.

Control. Leaf spot, like spur blight and mildew, is rarely serious enough to require control. On black raspberries the anthracnose sprays are beneficial. The more serious attacks on dewberries also have been controlled very satisfactorily by these sprays as outlined on page 26.

DISORDERS CAUSED BY LOW TEMPERATURES, WIND AND SPRAY MATERIALS

Winter Injury

Raspberries, like many other plants, are subject to considerable injury due to freezing. In general, red varieties are considered to be more hardy than blacks; however, in the case of reds, hardiness varies considerably with the variety. The Latham seems to stand lower temperatures than many of the other red forms. The black variety Older is also considered to be quite hardy. The Cuthbert is more subject to freezing injuries and for this reason does not have so wide a northern range of distribution as some of the other red raspberries.

Symptoms. There are several types of injuries brought about by low temperatures during the late fall and winter. The particular type of damage produced depends, to a large degree, on the extent of the original injury. Entire canes and occasionally whole plants may be killed. If the roots are not badly injured, new canes will be produced and the plant will have much the appearance of the one shown in Figure 30, in which dead fruiting canes are surrounded by a vigorous growth of new shoots. Raspberries, as a rule, grow late into the fall and all varieties have canes with more or less succulent growth at the tips at the time of the first fall freezes. Most of this growth is killed back to the more mature wood. However, since this growth would normally be pruned off, no damage is done if the injury does not extend too far back from the tip.

Another quite common symptom of winter injury consists of wilting and dying of the new growth on the fruiting canes. Usually, this takes place before the new shoots are two inches long, but, in some cases, the new shoots are larger. This type of symptom is brought about by the killing of certain of the cells in the cane while the buds themselves are not injured. Poisonous products move from the dead cells of the bark and cambium and probably also from the wood, and indirectly interfere with the movement of water. This in turn causes the wilting of the new shoots. In some cases this type of injury is not severe enough to cause wilting and death of the new shoots of the fruiting canes. In these cases, the shoots are short, bushy, and produce small seedy berries. Under some conditions the buds on the canes are killed with little injury to the cane itself. Injury to the buds also

sometimes induces the production of clusters of shoots on the fruiting canes. These may have the appearance of small "witches brooms."

Prevention. In attempting to prevent a trouble such as winter injury, it is quite natural to consider first the selection of more hardy varieties. Unfortunately, in the case of raspberries, those varieties which are more desirable from the standpoint of quality of fruit are also more subject to winter injury than are some other kinds. However, over the greater part of the Lower Peninsula of Michigan, all

Fig. 30.—Winter injury on a Columbian plant.

of our common varieties of raspberries may be grown successfully, and it is not necessary to sacrifice quality for hardiness if one takes advantage of the few principles of prevention of winter injury which may be used. The most important of these is the selection of a well drained soil for the planting. Raspberries are very sensitive to excessive amounts of soil moisture. Plants may grow well through the

summer on rather wet locations, but, if there is any tendency for water to collect on the surface in the late fall or during the winter, damage from freezing is almost sure to result.

Plants are more subject to winter injury in fields which have been poorly cultivated during the earlier part of the season. Rapid growth late in the season also predisposes plants to freezing injury.

Winter injury to dewberry canes is avoided by laying the canes down in the fall and covering them with soil. However, due to the breaking of canes and the cost of operation, this practice is of little value with raspberries in this state.

Methods for the prevention of winter injury may be summarized as follows:

1. Plant raspberries only on well drained soil.
2. Keep the planting well cultivated during the first half of the season.
3. To check growth and make the canes more resistant to freezing, sow a cover crop of oats, or of some other suitable plant, about the middle of August.

Frost Injury

Crop reduction due to frost injury is not so common on raspberries as on some other plants. However, on an average of once in each six to eight year period, spring frosts are late enough to cause killing of blossoms. The whole blossom cluster may be killed; more often, how-

Fig. 31.—Frost injury showing white marks along the sides of the main veins of the leaf.

ever, only a few of the blossoms in each cluster are injured, and the crop is not completely destroyed.

Each season the earliest of the new cane growth of red raspberries is frosted. Sometimes only the leaves are injured but quite often the growing tips are killed. This induces lateral bud growth and causes the production of a cane which is much branched near the base.

Frost injury to the first leaves produced on the fruiting canes is almost a seasonal occurrence. Sometimes the tips of the young leaves are killed outright, but more often, certain characteristic frost markings, involving very little of the tissue, are formed. Frequently, leaves of this latter type are more narrow than normal and have the appearance of having been stretched. Small ribs of elevated tissue are common and usually there are small white marks about a sixteenth of an inch long and about as wide as a pencil mark on each side of the main veins. In the milder forms, the leaves are normal in shape but show the white lines along the veins as shown in Figure 31. Leaves which are larger than half grown at the time frosts occur usually do not show the white lines; but, if injured at all, have portions killed. Leaves which are smaller at the time of the frost show no effects until after they have expanded. Stippling then begins to be noticeable. Once the stippling has been produced it remains evident so long as the leaves are green. Thus the symptoms of frost injury may be seen well towards the middle of the summer. Small, more or less round white spots occurring promiscuously over the leaf, caused by the feeding by red spiders, are sometimes confused with the stipple type of frost injury described above.

Frost injury on the leaves occurs on all varieties of raspberries but causes little or no direct loss. Its chief significance lies in the fact that it is sometimes confused with mosaic. Frost injured plants are sometimes destroyed under the impression that they have a virus disease.

Wind Injury

Injuries on raspberries due to strong winds, occur in several different forms. In the case of a considerable part of these injuries, such as the blowing down and the breaking of canes and the whipping of tips of black raspberry canes, the cause is obvious. However, there is a form of injury to young canes of black raspberries which is more confusing. Often about the time the new canes reach a height of a foot or more, the tips begin to wilt and in a few days the canes die. In other cases death may not progress so rapidly. Tips may wilt and even die, while the remainder of the cane is alive; secondary buds may start, producing a bushy cane growth before the cane dies. Canes of the types described may be found each season in the majority of Cumberland fields and to a lesser extent usually in fields of other black varieties. Instances are on record in which as many as twenty per cent of the new canes have been lost in this manner.

While wind is the chief cause of the breaking of new canes, hitting the canes with cultivators or other tools will produce the same results. This type of injury is made possible by the very weak connection which, at first, the new cane has with the crown. When the affected cane is

broken off and the end which was attached to the crown is examined, it is found that there is a ring of irregularly broken bark and callus and that the pith has dried and contracted. Some of these canes look as if they had been girdled by some kind of gnawing insect. The original break in the bark is made by the swaying of the young cane in the wind or by movement due to other causes before enough wood is produced to hold the cane rigid. Callus formation usually does not repair the injury. The small amount of wood which was formed before the break occurred continues to function and, for a time, supplies the cane with moisture in constantly decreasing quantities. Such weakened canes may live for several days if the soil is moist, but, as the soil becomes drier or the weather becomes warmer, they wilt and die.

Fig. 32.—A Cumberland black raspberry plant which had all of the new canes injured by a strong wind. The canes show various stages of this kind of injury. The cane stub at the right shows callus formation following the breaking of the bark on one of these canes.

There is no very satisfactory prevention for cane breaking due to wind. However, injuries of this type caused by striking the young canes with cultivators or other implements can be avoided. It is well to keep in mind that breaking of canes is worse in second year plantings than in plantings of any other age. This is due to the fact that in the second year the new canes begin to be stocky and to produce an upright growth, while the fruiting canes are not yet high enough to offer any appreciable support.

Spray Injuries

Raspberries, probably more than any other fruit plant, are subject to injuries from sprays. Under certain conditions, all of the standard sprays such as Bordeaux mixture, liquid lime-sulphur, and dry mix have caused loss of leaf surface. A common type of injury consists of

the burning of the edges of the leaves and the tissues between the veins. Often such leaves yellow and drop. The burning and leaf fall is sometimes so severe that the plants may be nearly completely defoliated. Often this is true of plantings which have received an application of summer strength lime-sulphur late in the season. Raspberry plantings in apple, pear, or cherry orchards are sometimes injured by the "drift" from the apple or cherry sprays.

Old raspberry leaves are more subject to injury than are young leaves. Defoliation is usually more severe on fruiting canes than on the new canes and sprays applied late in the season are more likely to cause injury than are the early sprays.

Plantings reported as sprayed with Bordeaux mixture, and others said to have been sprayed with liquid lime-sulphur have shown, in some cases, a type of mottling similar to mosaic. This injury takes the form

Fig. 33.—A leaf from a Cumberland black raspberry plant which was sprayed with liquid lime sulphur about the blossoming time. Nearly all of the plants in some sprayed fields show this type of mottling.

of blotches of various sizes. These are usually quite evident on the upper side of the leaf. On the lower side of such spots, the spray mixture applied can usually be found. The yellow splotches on the upper side correspond in size and shape to the spray covered spots on the

lower side of the leaf. Spray material falling on the upper side of the leaf has not been found to have caused yellow spots. The reason for this is not known, but the injury may be correlated with the occurrence of breathing pores on the lower side of the leaf. It may well be that some product of the spray mixture enters the pores and causes a bleaching of the green coloring matter.

This type of injury in itself is not believed to cause much damage. In fields which are to be rogued, however, it may be confused with mosaic. Before mosaic plants are rogued from a planting, it is important, in fields which have received a summer spray, to determine whether spray splotching has been produced. If there is injury of this type, it can, in most cases, be distinguished from the mosaic mottling by the presence of the spray material, by the character of the spots, and by the position of the spotted leaves on the plant. If the spray splotching is so common as to obscure mosaic symptoms, as is sometimes the case, it may be better to delay roguing until the mosaic plants can be distinguished with greater certainty.

NOTES ON VARIETIES

Varieties of raspberries show great variation in resistance to disease. All varieties of red and purple raspberries are resistant or immune to orange rust, and the red varieties are quite resistant to anthracnose. All known forms of mosaic dwarf susceptible black varieties more than reds. In general, cane blight is more severe on blacks, and spur blight causes more injury on reds. Within the red and black groups, there is also much variation in the symptoms of the same disease on different varieties. It is not at all necessary for the grower to familiarize himself with all of these variations, but it is desirable to recognize disease symptoms on the variety or varieties grown.

The following descriptions of the chief Michigan grown varieties, in their relation to disease susceptibility, are given with the hope of simplifying control recommendations for individual varieties. Disease resistance, however, should not, as considered in this bulletin, be selected as a basis for determining the variety of raspberry to be grown. It is an interesting fact that nearly all of our leading varieties of raspberries are generally considered to be more susceptible to disease than are many of the varieties of less commercial importance. In the case of some varieties and with some diseases, there is some basis for this conclusion but a large share of this general conviction is a result of increased opportunity for disease spread and for wider observations on the destructiveness of disease on widely grown varieties.

With the raspberry varieties now available, it does not pay to sacrifice quality and other desirable characteristics for disease resistance, alleged or otherwise. Diseases of any of the commercial varieties of raspberries can be successfully and economically controlled in this state. Therefore it is more satisfactory to select the variety of highest quality which is best suited to local conditions and control the disease rather than select an inferior variety which is disease resistant.

Red Varieties

Cuthbert. The diseases which require control measures are curl, mosaics, and crown gall. The variety is very susceptible to curl, but more resistant to infection by mosaics than King or Latham. It is somewhat susceptible to a mild mosaic which causes very little stunting. Plants of this type cannot often be successfully rogued but, wherever possible, their use in new plantings should be avoided. Streak and orange rust have not been found on this variety. It is slightly susceptible to leaf spot, anthracnose, spur blight, and wilt but is rarely severely damaged by any of these diseases. However, it is more subject to winter injury than most other red varieties.

Control Measures. Select plants having little or no crown gall, curl, or mosaics and rogue for curl and severe forms of mosaic.

King. Mosaics and crown gall are the diseases of most importance on this variety. It is rather susceptible to all of the known forms of mosaic, and spread is more rapid than in Cuthbert. Mild forms are more widely distributed. Nearly all of the plants in some fields show mild mottling on the leaves which are produced early in the spring. This type does little damage to the King, but the virus, when transferred to black raspberries, causes marked dwarfing. Such plants should not be placed close to black raspberries. Other forms of mosaics are common and cause considerable dwarfing. Curl is extremely rare and streak is unknown on this variety. It is apparently immune to orange rust and is rarely injured by anthracnose, spur blight, wilt, or leaf spot though it is more subject to leaf spot than are most other red varieties. Mildew causes yellow spots on the leaves which are often confused with mosaic symptoms but the disease causes very little direct injury. Crown gall is severe under some conditions, but plants seem to be more resistant than Cuthbert.

Control Measures. Select relatively disease free plants and rogue for the more severe forms of mosaic.

Latham. In its general reaction to disease, the Latham resembles the King. It differs in being much more susceptible to curl and mildew. The latter is often severe and causes considerable injury. Like the King, it is quite susceptible to a mild form of mosaic which causes no appreciable damage except when transferred to some black variety. In general, the Latham may be said to be rather susceptible to infection by the mild as well as the more virulent forms of mosaic. The milder form is becoming well distributed through certain nursery stock and in some fields, all of the plants carry the virus of this form of mosaic. Leaf spot, anthracnose, wilt, and cane blight are minor diseases, and orange rust is not known on this variety.

Control Measures: Select relatively disease-free plants and rogue for curl and the more severe forms of mosaic. Control measures for mildew are needed, but, as yet, no safe recommendation is available.

Viking. This variety was originated in Ontario and is a cross between Marlboro and Cuthbert. It reacts to disease in much the same way as Cuthbert. All plants which have been tested carry a mild mosaic virus which apparently causes no immediate injury to reds. This virus

readily crosses to black varieties and causes considerable stunting. Vikings should not be planted close to black varieties.

Control Measures. Select the healthiest plants available and rogue for curl and the severe forms of mosaic.

Marlboro. This variety is somewhat similar to Cuthbert in its reaction to diseases. It more often carries a mild form of mosaic, but is slightly less susceptible to curl. It is more subject to spur blight though this disease is not often serious.

Control Measures. Select the best plants available and rogue for curl and the more severe forms of mosaic.

Ranere (St. Regis). Very resistant to the more severe forms of mosaic and not injured by curl. Many plants carry the virus of a mild form of mosaic which does not cause immediate injury to reds. This variety is more resistant to crown gall than most other red varieties and it is very resistant to other raspberry diseases.

Control Measures. Select the best plants available and rogue for the more severe forms of mosaic.

Ohta (Flaming Giant). The Ohta is a very hardy and vigorous variety. Mosaics cause very little dwarfing and curl is very rare if it occurs at all. The variety is very resistant to all other raspberry diseases with the possible exception of crown gall.

Control Measures. Select the best plants available and, if necessary, rogue for the more severe forms of mosaic.

Hybrid Varieties

Columbian. On Columbian the diseases which are of most importance are crown gall and mosaics. Galls cause more injury on this variety than on Cuthbert. It commonly carries a virus relatively mild in its dwarfing effects but readily detected by the mottling of the leaves. It is also subject to more severe forms of mosaic. Plants are sometimes attacked by curl but, under field conditions, no injury has been observed. Anthracnose is sometimes severe; but the variety is very resistant to other raspberry diseases such as leaf spot, spur blight, cane blight, and it is apparently quite resistant to wilt.

Control Measures. Select plants as free as possible from gall and virus diseases and rogue for the more severe forms of mosaic. Spray for anthracnose if this disease has a tendency to be severe.

Royal Purple. Mosaics symptoms are less distinct on this variety than on Columbian, and anthracnose and crown gall are less severe. Other diseases affect it in much the same way as they do Columbian.

Control Measures. Select the best plants available.

Cardinal. The Cardinal is probably the most disease resistant of the purple cane varieties. Mosaics cause very little injury though all plants which have been tested carry a virus. In most cases, symptoms of mosaic are almost completely masked. It is not safe to plant this variety near black raspberries. The variety is often stunted by mildew. It is quite resistant to crown gall and anthracnose and is not injured by any of the minor diseases of raspberries.

Control Measures. Select the best plants available.

Haymaker. The Haymaker is more resistant to infection by curl than is Cuthbert but more rapidly dwarfed after infection. It is more resistant to crown gall and anthracnose than Columbian, but, in other respects, it is similar to Columbian in its reaction to diseases.

Control Measures. Select plants as free as possible from disease and rogue for curl and the more severe forms of mosaic. Spraying for anthracnose may in some cases be advisable.

Black Varieties

Cumberland. Because of its high quality, the Cumberland has become the leading black raspberry of Michigan. It is quite susceptible, however, to diseases, and profitable production often depends on disease control. Streak, all known forms of mosaic, and one form of curl attack this variety and cause severe injury. Under some conditions, curl and some of the mosaics spread rather rapidly. Anthracnose, orange rust, and wilt cause considerable damage and new canes are quite subject to wind injury. Galls are common on the plant crowns and canes but injury is not so severe as in the case of some of the reds. Leaf spots and mildew are of little importance.

Control Measures. Select relatively disease-free plants, preferably from young plantings. Plant early and remove all old anthracnose infested parts. Rogue for orange rust, streak, curl, and mosaic. Spray for anthracnose. As a rule, it is best not to plant Cumberland near red or purple varieties or near wild red raspberries.

Plum Farmer. This variety is more resistant than Cumberland to orange rust and slightly more resistant to anthracnose, wilt, and wind injury. It is very resistant to curl and has considerable resistance to infection by mosaics.

Control Measures. Very little if any roguing for curl and orange rust is necessary; otherwise the treatment is the same as in the case of Cumberland.

Gregg. This variety in its reaction to disease is similar to Cumberland. It is slightly more resistant however to curl, wilt, and anthracnose.

Control Measures. See Cumberland.

Kansas. The Kansas is very resistant to orange rust and curl, and slightly more resistant than Cumberland to mosaics, streak, wilt, and anthracnose.

Control Measures. The best control treatment for this variety is the same as that given for the Cumberland. However, less rouging for curl and orange rust is required.

SUGGESTIONS FOR RASPBERRY DISEASE CONTROL

1. **Use vigorous disease free plants.** Every new planting should be started with vigorous plants which have come from plantings which have a minimum amount of mosaic, curl, orange rust, and streak. The best plants are usually secured from young fields. Where possible the plants should be taken directly from the mother plants to the new field.

2. **Remove the old canes from black raspberry tips before planting.** Anthracnose is carried to the new field on the so-called "tails." Removing these and covering all parts of the tips with soil greatly reduces anthracnose in the new planting.

3. **Rogue first year plantings several times for curl, mosaic, streak, and orange rust.** This is one of the most important measures for raspberry disease control. The diseases named above can be practically eliminated the first year, making subsequent control relatively simple and inexpensive.

4. **Rogue older plantings if the percentage of disease is not too high.** Fields more than one year old and having more than 10 per cent curl, mosaic, streak and, orange rust rarely pay for roguing. If the percentage is lower careful roguing may be of value. No field which is well rogued in its first year should have more than one per cent of the plants diseased the second year. Old fields having less than two per cent of these diseases can be, as a rule, successfully rogued.

5. **Plant black raspberries at a distance of at least 50 yards from reds.** Red varieties, especially King and Latham, commonly act as carriers of mosaic viruses which do little damage to reds but which cause severe stunting of blacks. Wild red raspberries in the immediate vicinity of a black planting, are also sources of infection. Spread of mosaics to blacks from wild reds, is sometimes very severe especially if the wild plants are in shaded locations where aphids multiply rapidly.

6. **Spray black raspberries for anthracnose.** Applications should be made as follows:

    1. When the buds show green. Use 5 to 10 gallons of liquid lime sulphur and add enough water to make 100 gallons.
    2. About one week before the blossoms open. Use Bordeaux mixture 4-8-100. Two gallons of liquid lime sulphur with enough water added to make 100 gallons, applied at this time will also control anthracnose but there is more danger of burning the leaves.

    Sprays applied after blossoming, are likely to cause leaf injury. Red raspberries are usually not sprayed. Purples may be sprayed if anthracnose becomes severe. Dewberries should be sprayed as outlined above for black raspberries.